DCM555 - Data Communications
Lab 6
Transferring Waveforms over the LAN

Name: _____ St. #: _____ Section: _____

(**Note**: Show all of your calculations, express your answer to the appropriate number of significant digits (at least three) and use the correct units in your answer. Place your answer in the space provided.)

Lab Objectives

- to review LAN & GPIB configuration procedures for remote control of Agilent instruments
- to access and vary settings for the built-in waveforms of the Agilent 33220A Function /Arbitrary Waveform Generator
- to use Agilent Visual Engineering Environment (VEE Pro) to create arbitrary waveforms and send them to the Agilent 33220A Function /Arbitrary Waveform Generator over the LAN for production

Components Required

- none

Equipment Required

- Agilent 33220A Arbitrary Waveform Generator
- Agilent/Keysight DSO-X 2002A Mixed Signal Oscilloscope
- Agilent Visual Engineering Environment (VEE Pro)

With DSO-X 2000 series Oscilloscope

Lab Exercise

Built-in Arbitrary Waveforms

1. Turn on the Agilent 33220A Function /Arbitrary Waveform Generator and the Agilent DSO-X 2002A Mixed Signal Oscilloscope. Determine the LAN address for each instrument/device to be used and record them below. *Do not change any of the LAN/IP addresses and configuration!*

- Agilent 33220A Function /Arbitrary Waveform Generator: Utility > I/O > LAN, Current Config

33220A IP Address _____

- Agilent DSO-X 2002A Mixed Signal Oscilloscope: Utility > I/O > LAN Settings, then IP Address

DSO-X 2002A IP Address _____

2. Turn on one of the lab station PCs and log on.

3. From Windows launch VEE Pro (from the desktop icon **Agilent** folder...).

4. It will be necessary to first establish the LAN connection interfaces in VEE Pro for all devices to be used. Follow the procedure used in the previous Intro lab to initialize the VEE LAN(TCP/IP) interface.

NOTE: It is often a good idea to keep a VEE Pro *template file* set up for your lab station. If the "Save I/O Configurations with Program" box is checked when saving the file in the last lab, all interface configuration data will be retained, and it will be unnecessary to repeat these steps the next time, when you simply open the template file in VEE Pro, then *save it with a new name*, keeping your template file pristine for future use.

5. We'll now use VEE to access a function built into the 33220A which produces an AM waveform. Create a "Direct I/O" box for the 33220A into the VEE workspace. Enter the following Standard Commands for Programmable Instruments (SCPI) program into the 33220A transaction box:

```
"FUNC:SHAP SIN"
"VOLT:UNIT VPP"
"VOLT 1.0"
"FREQ 100E3"
"AM:INT:FUNC SIN"
"AM:INT:FREQ 1E3"
"AM:DEPT 50"
"AM:STAT ON"
"OUTP ON"
```

When completed, the transaction box should appear similar to Figure 1. Examine the command explanations and make sense of them for yourself:

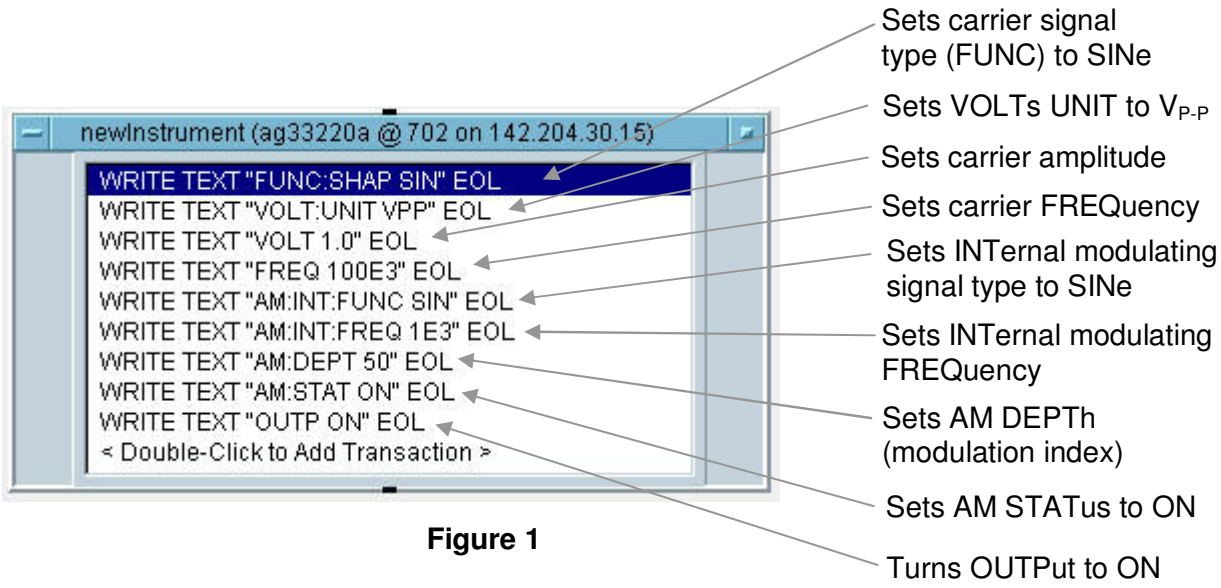
newInstrument (ag33220a @ 702 on 142.204.30.15)
WRITE TEXT "FUNC:SHAP SIN" EOL
WRITE TEXT "VOLT:UNIT VPP" EOL
WRITE TEXT "VOLT 1.0" EOL
WRITE TEXT "FREQ 100E3" EOL
WRITE TEXT "AM:INT:FUNC SIN" EOL
WRITE TEXT "AM:INT:FREQ 1E3" EOL
WRITE TEXT "AM:DEPT 50" EOL
WRITE TEXT "AM:STAT ON" EOL
WRITE TEXT "OUTP ON" EOL
< Double-Click to Add Transaction >
Sets carrier signal type (FUNC) to SINe
Sets VOLTs UNIT to VP-P
Sets carrier amplitude
Sets carrier FREQuency
Sets INTernal modulating signal type to SINe
Sets INTernal modulating FREQuency
Sets AM DEPTh (modulation index)
Sets AM STATus to ON
Turns OUTPut to ON

Figure 1

6. Connect the 33220A output to the DSO-X 2002A probe. Set the time base to 500µs/div. Run the program. An AM waveform should appear on the oscilloscope display. "Stop" the DSO-X 2002A and view the AM waveform. Use the oscilloscope cursor functions to measure the carrier frequency and modulating frequency (from the envelope). Also determine the modulation index. Record your values below:

$$\text{Recall} \quad m = \frac{B - A}{B + A}$$

f_C = _____

f_i = _____

m = _____

7. Modify your program to make the carrier frequency, the intelligence frequency and the modulation index all variable from a slide bar (from Data > Continuous > Real64). (Don't forget to *put a space before the "*.)

As each slide bar is inserted, examine the "Properties" window on the left of the screen. Under "Behavior" select the "Auto Execute" pull-down menu. Change the value from "False" to "True". This causes the VEE program to automatically run whenever the slider position is changed. From the "Properties" window you can also change the slider titles from "Real64" to more appropriate names, like Carrier Freq., etc.

When completed, the program should appear similar to Figure 2. Set the minimum and maximum values for each slide bar as shown:

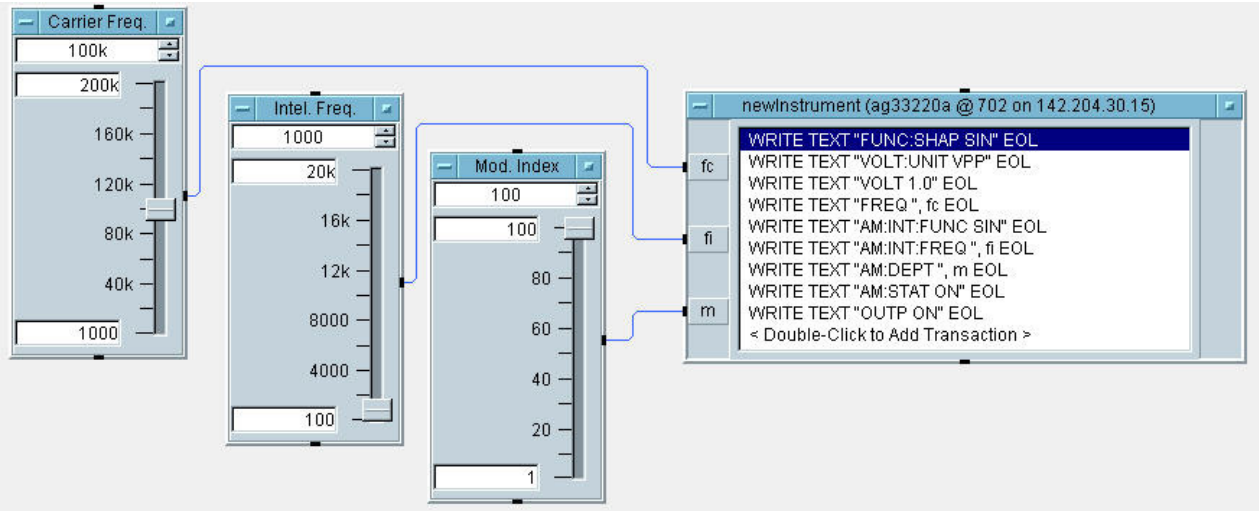

Figure 2

8. Turn the DSO-X 2002A to "Run". Vary each of the slide bars in turn and look at the DSO-X 2002A display. Describe what happens:

_____

9. Set the AM waveform for a 100kHz carrier, a 1kHz intelligence and a modulation index of 100%. Set the time base to 500µs/div. Capture and save the DSO-X 2002A *time domain* display for your report.

10. Select the frequency domain function of the DSO-X 2002A (Math > FFT). Turn Off the time domain display. Under Settings, adjust the Center frequency to that of the carrier and the Span to 10kHz. Use the cursor functions to measure the three peak frequencies and powers (in dBV). Record them below:

f_1 = _____ P_1 = _____

f_2 = _____ P_2 = _____

f_3 = _____ P_3 = _____

Capture and save the DSO-X 2002A *frequency domain* display for your report.

Adjust each of the sliders and monitor what happens in the spectrum. By varying the intelligence frequency lower and lower, try to determine the maximum resolution of the DSO-X 2002A FFT, that is, the minimum discernable frequency separation between spectral peaks.

FFT resolution = _____

There are other built-in modulation types and arbitrary waveforms in the 33220A, all of which can be accessed from a User I/O interface as above. (Search for the 33220A User Manual at www.agilent.com)

User-Defined Arbitrary Waveforms

11. We'll now use VEE to generate waveforms. Start a *new* VEE Pro program (File > New). Select Device > Virtual Source > Function Generator and place the object on the work space. Then select Display > Waveform and place the object on the work space. Join the output of the function generator ("Func") to the input of the display ("Trace 1").

Change the Function to Sine, and the Frequency and Time Span both to 1.The program should appear similar to Figure 3.

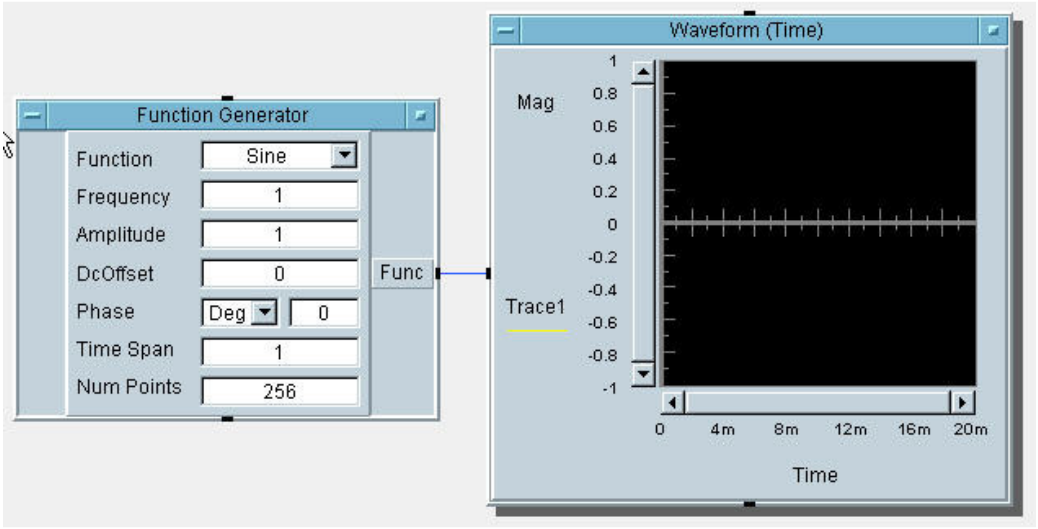

Figure 3

12. Push the "Play" button. Precisely what do you see?

_____

_____

Use the horizontal and vertical sliders to move around the display. Right click on the Waveform Display object and experiment with the Auto Scale and Zoom features. Also experiment with the settings under Properties > Scales.

13. Move the mouse cursor over the line connecting function generator and display. It will change into a magnifying glass as shown in Figure 4.

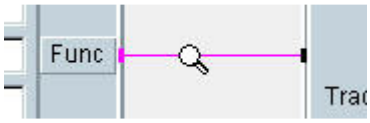

Figure 4

Click on the line. This shows the contents of the "waveform". Describe precisely what information about the waveform is displayed:

_____

_____

14. How does the number of elements in the array correspond to the number of points set in the function generator object?

_____

Record the value in any element of the array (*except* the first) and the element index. (You will use this later.)

Array value = _____

Array index = _____

15. We will now prepare the waveform data for transfer to the 33220A Arbitrary Waveform generator. The waveform data is actually a composite data type consisting of the array and a Time Span. We need to Unbuild the waveform first. Insert an Unbuild Waveform object into the work space from Data > Unbuild Data > Waveform. Double click on the object. Insert two alphnumeric displays from Display > Alphanumeric and connect them to the "Real64 Ary" and "Time Span" outputs of the Unbuild object. The program should appear similar to Figure 5.

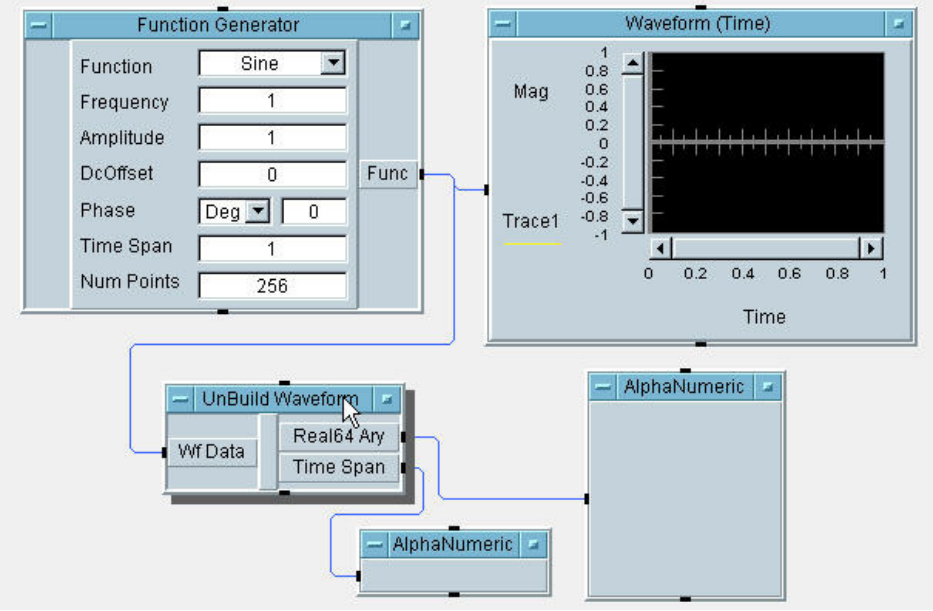

Figure 5

Push the "Play" button. What do the two alphanumeric displays show? (Use the slide bar if present.)

_____

16. We will now convert the data to a *string*, that is to say, 8 bit digital samples of will be treated as ASCII character. This is a data format which can be received and understood by the 33220A. Insert a To String object into the work space from I/O > To > String. Right click on the To String object and select Properties. A Properties side panel will appear on the left side of the screen, as shown on the left of Figure 6.

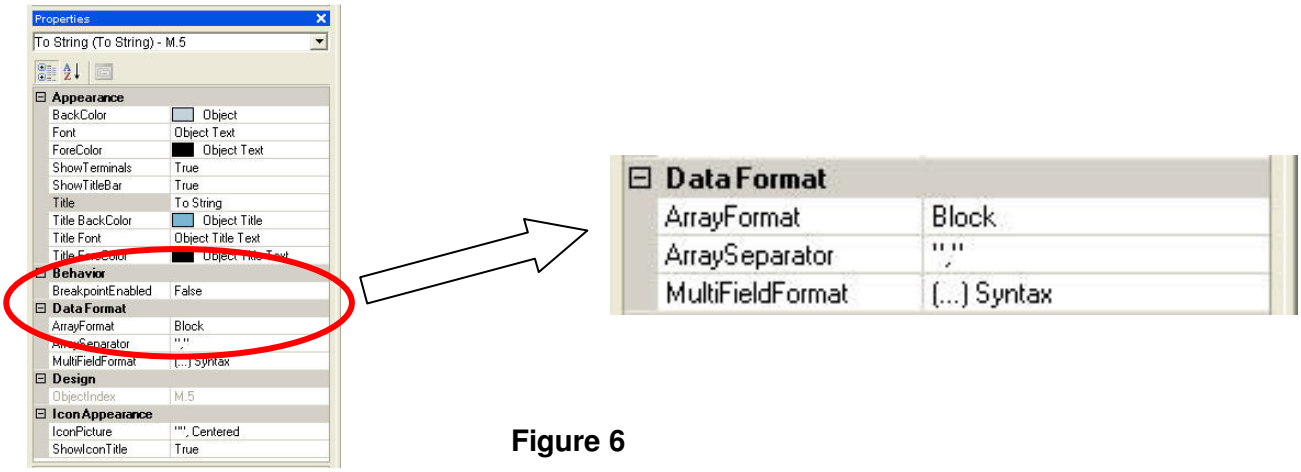

Figure 6

In the Data Format section, ensure that the Array Format is Block, and the Array Separator is set to a comma (between double quotes). This uses a comma as the *delimiter* between each character of the string, which is formed from the array. The Data Format part of the To String Properties box should appear as shown on the right of Figure 6. This will insert an ASCII comma character between sample characters.

In the To String object, double click on the Transaction Line and form a transaction as shown in Figure 7. Make sure the *String Format* is selected.

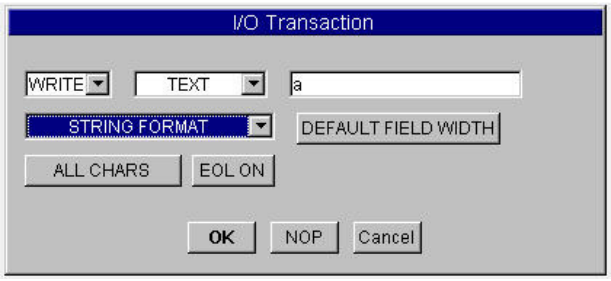

Figure 7

Select OK and connect the output of the Unbuild Waveform object to the "Real64 Ary" input of the To String object. This part of the program should appear similar to Figure 8. The Unbuild Waveform object separates the waveform Time Span from the actual waveform samples.

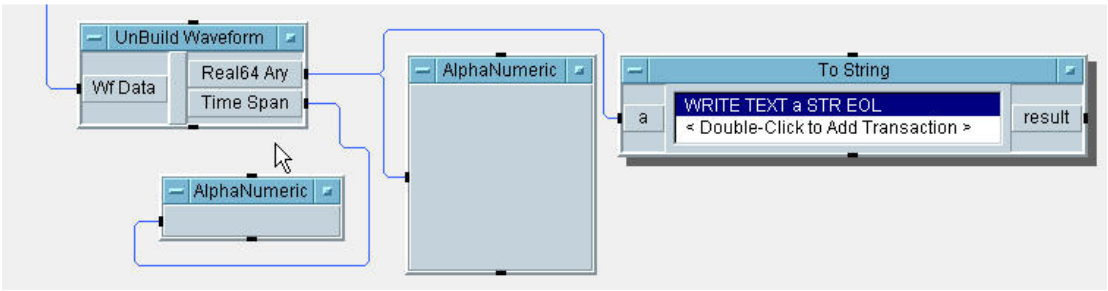

Figure 8

17. Insert a Logging Alphanumeric object into the work space from Display > Logging Alphanumeric. (This is the type of display used for strings.) Connect the Result output of the To String Object to the Logging Alphanumeric input.

Push the "Play" button. Describe how the Logging Alphanumeric Display data differs from the Alphanumeric Display of the array?

_____

_____

18. From the Instrument Manager, insert a 33220A transaction box into the work space. Enter the following sequence of transactions:

"*RST"
"OUTP:LOAD INF"
"DATA VOLATILE, ", W
"FUNC:USER VOLATILE"
"FREQ ", F
"VOLT:UNIT VPP"
"VOLT ", A
"FUNC USER"
"OUTP ON"

This will insert three inputs on the transaction box, one each for frequency (F), amplitude (A) and the waveform string (W). When complete, the 33220A I/O transaction box should look like Figure 9. Examine the command explanations and make sense of them for yourself:

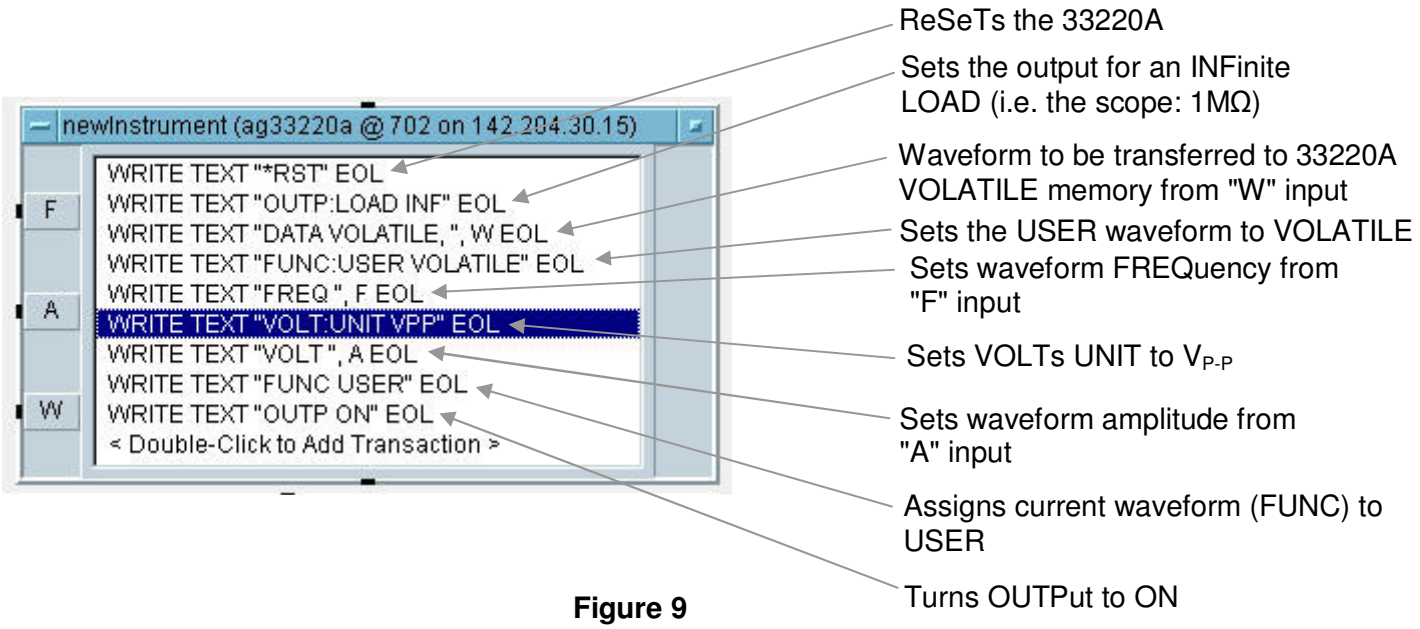
newInstrument (ag33220a @ 702 on 142.204.30.15)
F
A
W
WRITE TEXT "*RST" EOL
WRITE TEXT "OUTP:LOAD INF" EOL
WRITE TEXT "DATA VOLATILE, ", W EOL
WRITE TEXT "FUNC:USER VOLATILE" EOL
WRITE TEXT "FREQ ", F EOL
WRITE TEXT "VOLT:UNIT VPP" EOL
WRITE TEXT "VOLT ", A EOL
WRITE TEXT "FUNC USER" EOL
WRITE TEXT "OUTP ON" EOL
< Double-Click to Add Transaction >
ReSeTs the 33220A
Sets the output for an INFinite LOAD (i.e. the scope: 1MΩ)
Waveform to be transferred to 33220A VOLATILE memory from "W" input
Sets the USER waveform to VOLATILE
Sets waveform FREQuency from "F" input
Sets VOLTs UNIT to V_{P-P}
Sets waveform amplitude from "A" input
Assigns current waveform (FUNC) to USER
Turns OUTPut to ON

Figure 9

19. Insert sliders for F and A, as in Step 8. Set each slider to "Auto Execute" by setting the AutoExecute Behaviour in the slider Properties window to True. This will cause your VEE program to execute whenever the slider settings are changed, eliminating the need to push the Play button. (See Figure 10.)

Figure 10

Connect the Result output of the To String object to the W input.

When complete, your program should appear similar to Figure 11. Set the slider minimum and maximum values to those shown.

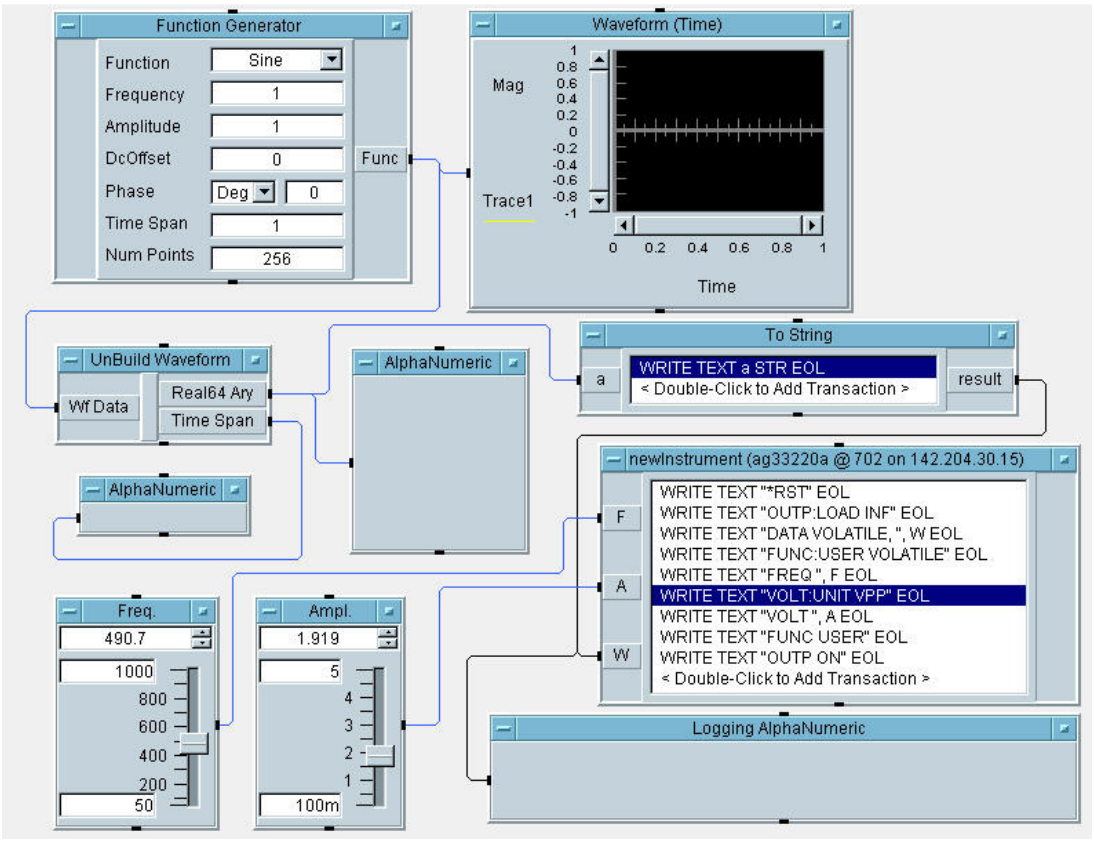

Figure 11

20. Ensure that the output of the 33220A is still connected to the probe to the DSO-X 2002A Oscilloscope. Push the Auto Scale button on the DSO-X 2002A. Push the "Play" button for your program. Watch the DSO-X 2002A scope display. After a delay, the 33220A waveform should change to that generated by your program.

Experiment with varying the function generator waveform, and the frequency and amplitude sliders. What takes place?

_____

_____

21. Change the number of points in the function generator object to 1000. Push "Play" and again examine the waveform using the magnifying glass. What changed?

_____

Change the number of points to 5 and push "Play". Describe the waveform displayed on the DSO-X 2002A?

_____

Also try other larger values (including *up to* 64k, that is, 65,536), pushing "play" then watching the DSO-X 2002A display each time. What do you notice about the time taken to transfer the waveform over the LAN?

_____

Return the number of points in the function generator object to 256.

22. Adjust the frequency slider to 1000 and the amplitude to 2. On the DSO-X 2002A, set the vertical amplifier to 500mV/div and the timebase to 2ms/div.

Capture and save the DSO-X 2002A *time domain* display for your report.

Activate the FFT of the DSO-X 2002A (Math > FFT) and turn off the time domain display. Under Settings set the Center frequency to 5kHz and the Span to 10kHz. Use the Cursor function to measure the spectral peak frequency.

Capture and save the DSO-X 2002A *frequency domain* display for your report.

23. Turn off the FFT display, and turn the time domain display back on with the timebase set to 500µs/div. In your VEE program, change the frequency in the function generator object to a non-integral value, such as 1.2. Push the "Play" button. Describe what you observe on the DSO-X 2002A

_____

_____

Capture and save the DSO-X 2002A *time domain* display for your report.

24. Adjust the time base back to 2ms/div. Reactivate the FFT and turn off the time domain display. Use the Cursor function to measure the spectral peak frequencies. Describe what you observe on the DSO-X 2002A.

_____

_____

_____

Capture and save the DSO-X 2002A *frequency domain* display for your report.

25. Using the Function menu of the VEE Function Generator, experiment with other waveforms, such as Square, and so forth. Change the amplitude and frequency settings and observe the corresponding changes in the time and frequency domain of the DSO-X 2002A.

Further study

26. In Step 6, did the measured values for f_C, f_i and m equal those specified by the program? If not, offer a possible reason why:

_____

27. Describe the advantage of the slide bar Auto Execute feature:

_____

_____

28. How does your estimate FFT resolution in Step 11 compare with the IFR spectrum analyzer used previously in A4056? Why is spectrum analysis (FFT) resolution important?

_____

_____

29. From the array index you recorded in Step 14, calculate what the array value should be. (Hint: You divided one sine wave cycle into 255 intervals.) How does this compare with the value recorded in Step 14?

Calculated Array value = _____

30. Based on Step 15, give the advantage and disadvantage of increasing the number of waveform points:

_____

_____

31. The waveform generated in your program was transmitted in a string format. Describe a disadvantage of transmitting the waveform as a string:

_____

_____

32. What was the difference between the 33220A waveform in Steps 22 and 23?

_____

_____

Based on the FFT Spectra for Step 22 and 23, describe the precautions which must in general be taken when transmitting an arbitrary waveform:

_____

_____

_____